Everyday Mysteries: Why don’t I fall out of an upside-down roller coaster?

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TOP: An amusement park steel rail roller coaster with its cars full of screaming riders; MyLoupe/UIG Via Getty Images.
BOTTOM: The Sidewinder at Six Flags Elitch Gardens in Denver, Colorado; Wikimedia Commons

Question: Why don’t I fall out when a roller coaster turns upside down?

Answer: As your roller coaster speeds along, the force of gravity pulls you down to the earth. However, it is not strong enough to overcome inertia. Inertia keeps you pressed against the bottom of the car with a force stronger than gravity.

Have you ever wondered how roller coasters stay on their tracks and why people can hang upside down in them? It is all a matter of different forces and different kinds of energy acting together.

No Engine, No Problem

A roller coaster does not have an engine. A lift or cable pulls it up the first hill. This builds up a supply of stored, or potential, energy that will be used to go down the hill as the train is pulled by gravity. Then, all of that stored energy is converted into kinetic energy, which is what will get the train to go up the next hill. So, as the train travels up and down the hills, it is constantly shifting between potential and kinetic energy.

The higher the hill the coaster is coming down, the more kinetic energy is available to push the cars up the next hill, and the faster the train will go. Plus, according to Newton's First Law of Motion, "an object in motion tends to stay in motion, unless another force acts against it." Wind resistance and the wheels along the track are forces that work to slow down the train over time. So, toward the end of the ride, the coaster has less energy. For that reason, the coaster's final hills tend to be made lower than the first hills.

Two Types of Coasters

There are two major types of roller coasters: wooden and steel. Wooden tracks are not as bendable as steel tracks, so usually they do not have complicated shapes, such as loops that flip passengers upside down. After tubular steel tracks were introduced in the 1950s, more complicated and adventurous coasters became possible. On this type of track, the wheels run along the top, bottom and side of the tube. They secure the train to the track as it travels through loops and twists.

Inertia Keeps You In Your Seat

In the loop-the-loop, upside-down design, inertia is what keeps you in your seat. Inertia is a resistance against change in direction. It presses your body to the floor of the loop as the coaster spins around.

Gravity is always pulling you toward the Earth, but at the very top of the loop, your inertia pushes you against the floor of the roller coaster car. This resistance to a change in motion is stronger than gravity. The loop must be an elongated loop, or ellipse, rather than a perfect circle. Otherwise, the force would be too strong for safety and comfort.

How do we know whether a roller coaster is safe? Engineers and designers follow industry standards and guidelines. The first “riders” are sandbags or dummies, after which engineers and park workers get to try it out. Would you want to be one of the first passengers on a new ride?

Russian Ancestor

The ancestor of the roller coaster is a 15th-century Russian sled ride called Russian Mountains.

One of the first roller coasters was built in France in 1817. It was known as Les Montagnes Russes à Belleville, or the Russian Mountains of Belleville.

In 1827, the Mauch Chunk Switchback Railroad of Summit Hill, Pennsylvania, built a track 18 miles down a mountain to transport coal. In 1873, it became a scenic, yet bumpy, pleasure ride. It remained in operation until 1938.

In 1884, La Marcus Thompson built the first American roller coaster, the Switchback Railway at Coney Island in Brooklyn, New York.

One of the first high-speed coasters was the Drop-The-Dip, which debuted at Coney Island in 1907. It was at this time that seat belts first started to be used in roller coaster cars.

Kingda Ka Is World's Tallest, Fastest

The first tubular steel coaster was the Matterhorn Bobsleds at Disneyland in Anaheim, California. It was introduced in 1959.

In 1975, Knott's Berry Farm in Buena Park, California, introduced the Corkscrew, the first coaster to turn passengers completely upside down.

The King Cobra at Kings Island in Cincinnati, Ohio, was the first roller coaster that allowed people to stand up. It was introduced in 1984.

The longest roller coaster built so far is the 8,133-foot Steel Dragon 2000, located in Japan's Nagashima Spa Land.

The tallest steel roller coaster in the world is the 456-foot-tall Kingda Ka at Six Flags Great Adventure in Jackson Township, New Jersey. Kingda Ka is also the world's fastest coaster. It travels at a speed of 128 miles per hour, with rides lasting only 50.6 seconds.

Quiz

1 Which selection from the article explains the various forces that allow a roller coaster operate?

(A) This builds up a supply of stored, or potential, energy that will be used to go down the hill as the train is pulled by gravity. Then, all of that stored energy is converted into kinetic energy, which is what will get the train to go up the next hill.

(B) On this type of track, the wheels run along the top, bottom and side of the tube. They secure the train to the track as it travels through loops and twists.

(C) Gravity is always pulling you toward the earth, but at the very top of the loop, your inertia pushes you against the floor of the roller coaster car.

(D) The loop must be an elongated loop, or ellipse, rather than a perfect circle. Otherwise, the force would be too strong for safety and comfort.

2 Which section of the article highlights the idea that safety features are tested before humans are allowed to ride roller coasters?

(A) "No Engine, No Problem"

(B) "Two Types of Coasters"

(C) "Inertia Keeps You In Your Seat"

(D) "Russian Ancestor"

3 What are the two CENTRAL ideas of the article?

(A) As roller coasters travel around their tracks they use kinetic and potential energy to stay in motion. Inertia is another force acting on a roller coaster that helps keep riders pressed to the outside of loops as the coaster spins around.

(B) Cables are used to pull roller coasters up hills without power from an engine. The wheels of roller coasters are designed to hug all the sides of the tubes to secure the train to its track while traveling upside down.

(C) Inertia prevents people from falling out of roller coasters and other forces help move the roller coaster around the track. Roller coasters have become more adventurous as people have learned how to use these forces to help keep riders safe through loops and twists.

(D) Roller coasters must have elongated loops shaped like ellipses to keep centripetal force from hurting riders. The first high-speed roller coaster was also the first to use seat belts to protect passengers.

4 Which detail from the article would be MOST important to include in a summary?

(A) Newton's First Law of Motion says objects in motion stay in motion.

(B) As roller coasters move, gravity is overcome by inertia.

(C) The two major types of roller coasters are wooden and steel.

(D) The world's tallest roller coaster is located in Jackson Township, New Jersey.